Chemical Enhancement of Fingerprints on Various Porous and Non-Porous Surfaces

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ABSTRACT

Latent fingerprints created by the transfer of perspiration from skin to a surface, require chemical enhancement to make ridge detail visible. This study contains two separate investigations, the first part investigates the chemical development of latent fingerprints on porous surfaces studying different paper types, using different chemical techniques. The second part of the study involves the analysis of fingerprints in which the transfer medium is blood. A side-by-side comparison of the available chemical techniques targeting a variety of porous and non-porous surfaces was carried out and the sensitivity of the chemicals was also tested through serial dilutions and concentration gradients of whole blood. Findings indicate that several conditions affect the quality of fingerprints. The degree of fingerprint ridge detail yielded during chemical development is influenced by factors such as the chemical technique used and the particular substrate from which the fingerprints are enhanced.

Keywords: *Latent, Ninhydrin, DFO, Blood*

INTRODUCTION

Fingerprint identification is based on two primary factors; uniqueness and permanence.

Fingerprints are a reproduction of friction skin ridges which release perspiration leaving the finger's ridge pattern on the surfaces upon contact. Latent prints deposited in this manner are invisible to the eye. Some means of development is generally required for their visualization.[1]

This study investigates the various techniques for the development of fingerprints. The initial part of the study relates to the chemical development of latent fingerprints on various types of paper. The different absorbent properties of such paper types were considered given that different paper types absorb the sweat of fingerprints differently. Ninhydrin and DFO, which both react with the amino acids present in fingerprints, were compared to investigate which chemical yields overall best results on a particular paper type.

The second part of the study further analyzed fingerprints present in blood, since often fingerprints are deposited in combination with biological material. An evaluation of different enhancement methods including Amido Black, Cyanoacrylate, Ninhydrin and DFO was carried out whilst studying both porous and non-porous surfaces. The effectiveness of the development techniques at different blood dilutions was also a parameter of the study.

Knowing which development technique yields the best results when faced with different surfaces in the forensic field is a valuable asset for forensic experts.

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MATERIALS AND METHOD

Subjects

The fingerprints used in this study were obtained by prior agreement from a volunteer. The volunteer's

fingerprint was used throughout all the phases of the study. The same one volunteer was considered in order to limit as much as possible any variations in the pressure with which the latent fingerprint was made. The thumb print was produced by applying medium pressure on a surface for five seconds. In the second part of the study, the thumb was first pressed onto a paper towel dampened with the blood, and then immediately touched onto the surface being investigated.

Surfaces/Substrates

The first part of the study investigated different porous surfaces. The fifteen paper types used in this study are art paper, rag paper, offset cartridge paper, bible paper, light colored marbled paper, newsprint, fax/thermal paper, brown paper, wax paper, bond paper, embossed paper, board paper, photographic paper, dark colored marbled paper and silver paper. Ten samples of each paper type, measuring 8cm x 6cm were utilized for each chemical test carried out.

The second part of the study utilized non porous surfaces namely glass, ceramics, adhesive tape and plastic and porous surfaces including paper, wood, gypsum and limestone. Ten samples of each surface studied, measuring 15cm x 15cm were used. All substrates were first cleaned using ethanol and handled through the use of latex gloves to prevent transfer of unwanted fingerprints.

The selection of substrates of this study was based on those most commonly encountered at crime scenes.[2]

Reagents and Methods

Ninhydrin and DFO were utilized in the first part of the study. The performance of Ninhydrin dissolved in three different solvents was investigated. Three different Ninhydrin working solution were prepared mainly Ninhydrin dissolved in Ethanol, Ninhydrin in Acetone and Ninhydrin in Methanol, to investigate any difference in the performance of the three Ninhydrin carriers.[3] Following treatment with Ninhydrin, the paper articles were examined for clarity after seven days to allow further fingerprint development. When Ninhydrin comes into contact with amino acids in fingerprint residue, a purple/red print is yielded.

The DFO working solution was also prepared and after exposing the paper articles to DFO, horizontal drying was ensured to avoid the formation of any fluorescent bands which can mask fingerprints. The coloured reaction is much weaker than that obtained with Ninhydrin and thus fluorescence examination is necessary. Quaser 2000/30 was used at excitation wavelengths in the range of 473-548nm and 503-587nm.[4]

In part 2A of this study, whole defibrinated horse blood was utilized. The use of defibrinated blood ensured that blood coagulation was prevented. Ninhydrin and DFO working solutions were applied to the porous surfaces. Excitation wavelengths of 400-469nm were utilized for fingerprints in blood, so as to enhance contrast as much as possible.[4]

For non-porous surfaces, fingerprints contaminated with blood were enhanced with Amido Black by first fixing the blood by immersion in methanol followed by immersion in working solution. This was followed by washes in an acetic acid-methanol solution and an acetic acid-distilled water solution.[3] Amido Black stains protein in blood to give a blue-black product as can be seen in Figure 1. Cyanoacrylate treatment was carried out by heating the cyanoacrylate in a high humidity fuming chamber. As the fumes condense, white-coloured latent prints develop.

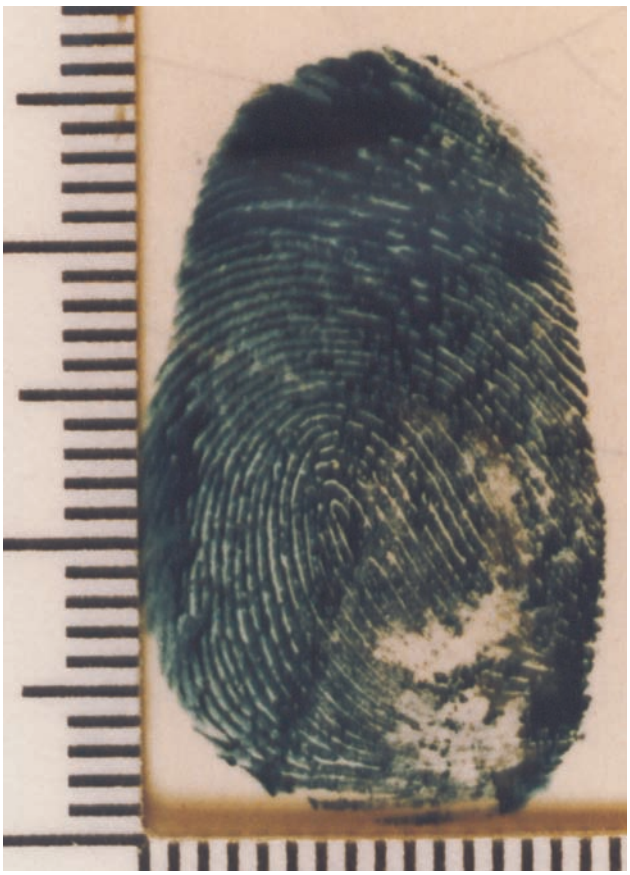


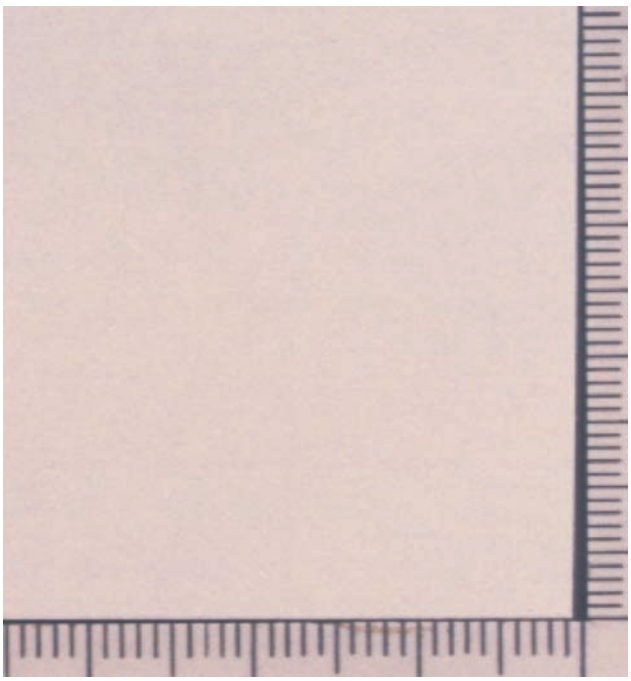
Fig. 1. A Fingerprint enhanced using Amido Black

Part 2B of the study was carried out on two porous (paper and gypsum) and two non-porous surfaces (glass and ceramics) using Ninhydrin and Amido Black for the respective surfaces. Whole defibrinated horse blood was serially diluted from concentrations ranging from 1:10 to 1:10,000, using physiological saline as the diluent. Fingerprints were obtained on all the surfaces. The appropriate chemical development followed, depending on the surface type. This was repeated using all the blood concentrations prepared. The above procedure was repeated using sequential touches where four fingerprints were sequentially made next to each other on the same surface without re-dipping the finger in the touch pad. Sequential touches of a surface provide a convenient, reproducible gradient of concentration of the transfer medium, in this case whole horse blood.

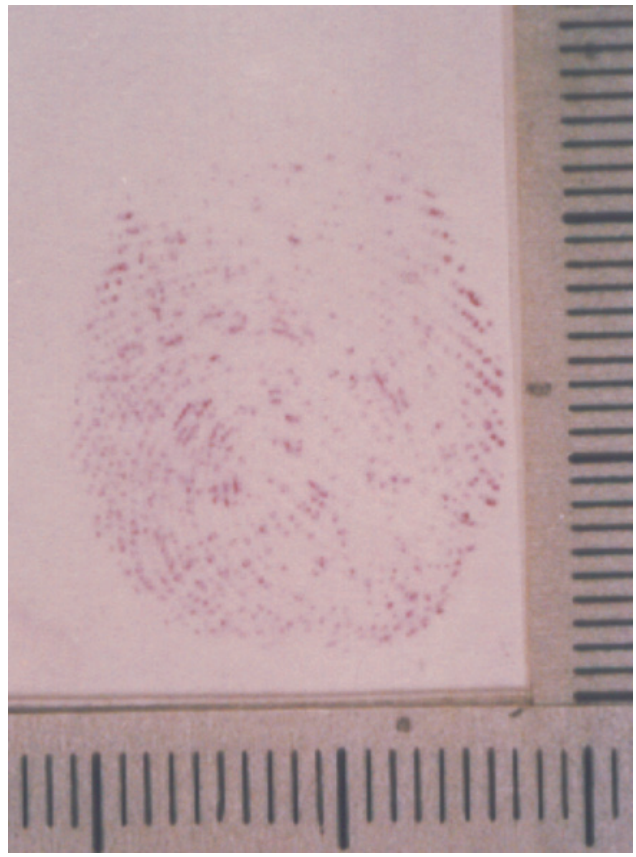
Fingerprint Analysis after Development

The fingerprints were photographed, dated and stored. To make a quantitative assessment of the study carried out, it was necessary to 'grade' the developed fingerprints. Developed fingerprints were 'graded' by studying the ridge detail yielded. A 'quality' scale from 0 (lowest ridge detail) to 3 (highest ridge detail) was used. [5]

Figure 2 depicts the grading standards used to grade developed prints.



Grade 0



Grade 1

Grade 2

Grade 3

Fig. 2. Ninhydrin - Developed Fingerprint Grading Scale

FINDINGS

Results were analyzed using SPSS statistical application. T-tests, Friedman tests, Two-way Analysis of Variance were utilized. T-tests and Friedman tests were performed for Part 1 and Part 2A whilst Regression Analysis was used for Part 2B.

In the first study, differences were noted in the performance of the four chemicals used on the selected substrates, Ninhydrin in ethanol yielding best results (overall grade 1.79) followed by Ninhydrin in acetone (overall grade 1.70), DFO (overall grade 1.64) and lastly Ninhydrin dissolved in methanol (overall grade 1.11). It was observed that both chemical and paper type are significantly affecting mean clarity since p-values obtained for both factors was < 0.05.

The findings of this study indicate that paper is a good source for developing latent prints, as it is generally absorbent. Amino acids have an affinity to the cellulose of the paper. Different paper types have different characteristics and this explains why varying results were obtained on different paper types. Table 1 indicates the first and second chemical preferences for the fifteen different paper types studied, according to the results yielded.

Table 1: First and Second Chemical Preferences for first phase of the study

Paper Type	Ninhydrin in Ethanol	Ninhydrin in Acetone	Ninhydrin in Methanol	DFO
Art Paper	×	"	"	
Rag Paper		"	×	
Offset Cartridge Paper	×	"		
Bible Paper	"	×		
Marbled Paper		×		"
Newsprint Paper	"	×		
Fax Paper	×			"
Brown Paper			"	×
Wax Paper	×			"
Bond Paper		"		×
Embossed Paper	"	×		
Board Paper	"	×		
Photographic Paper		×	"	
Coloured Marbled Paper	"	×		"
Silver Paper				"

" 1st Preference

× 2nd Preference

Study part 2A indicates that in the case of the non-porous surfaces (glass, ceramics, adhesive tape and plastic), Cyanoacrylate provided a higher estimated marginal mean (overall grade 2.13) than Amido Black (overall grade 1.80) whilst in the case of paper, wood, gypsum and limestone i.e. porous surfaces Ninhydrin (overall grade 1.43) yielded better clarity means than DFO (overall grade 1.25). However, in both porous and non-porous surfaces, the discrepancy noted between Cyanoacrylate and Amido Black and between Ninhydrin and DFO is not drastic. A p-value < 0.05 was obtained when the variable in consideration was the surface type. When chemical type was the factor studied, a value of 0.109 was obtained for p. This implies that surface type is the only factor that significantly affects mean clarity.

Once again, findings allow the deduction of the first and second chemical preferences for the porous and non-porous substrates studied as can be seen in Table 2.

Table 2: First and Second Chemical Preferences for second phase (Part 2A) of the study

Non-Porous Surface	**Cyanoacrylate**	**Amido Black**
Glass	×	"
Ceramics	×	"
Adhesive Tape	"	×
Plastic	"	
Porous Surface	Ninhydrin	DFO
Paper	"	×
Wood	"	
Gypsum	"	×
Limestone	×	"

" 1st Preference

× 2nd Preference

For Part 2B of the study, non-porous surfaces yielded higher scores than porous surfaces. For non-porous surfaces a linear relationship between blood concentration and mean clarity exists. However, this was not observed when the sequential touch technique was used on porous surfaces.

Table 3, illustrates the dilution or sequential touch which yielded best results on the particular porous or non-porous surface investigated.

Table 3: Dilution / Sequential Touch Yielding Best Ridge Detail for second phase (Part 2B) of the study

Serial Blood Dilutions with Amido Black

Non-Porous Surface	**1:10 Dilution**	**1:100 Dilution**	**1:1000 Dilution**	**1:10000 Dilution**
Glass	"			
Ceramics	"			
Serial Blood Dilutions with Ninhydrin				
Porous Surface	**1:10 Dilution**	**1:100 Dilution**	**1:1000 Dilution**	**1:10000 Dilution**
Paper	"			
Gypsum	"			
Sequential Touches with Amido Black				
Non-Porous Surface	**Sequential Touch 1**	**Sequential Touch 2**	**Sequential Touch 3**	**Sequential Touch 4**
Glass				"
Ceramics				"
Sequential Touches with Ninhydrin				
Porous Surface	**Sequential Touch 1**	**Sequential Touch 2**	**Sequential Touch 3**	**Sequential Touch 4**
Paper		"		
Gypsum		"		

" Preferred Dilution/ Sequential Touch

CONCLUSION

It can be concluded that both substrate and chemical technique have a significant influence on final ridge detail yielded. Knowing which technique to use, will ensure that fingerprints are developed using the method which will yield best possible results.

Prior identification of the best methodology for the development of latent fingerprints on any given surface will avoid subjecting the fingerprints to an inefficient development method which could potentially yield poor development results.

Even though technology continues to advance, fingerprints remain a valuable tool today due to their unique characteristics.

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